The effect of varying statistical structure of the input on typing and reading speeds

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The results to be reported here are part of a longer programme in which we are trying to learn more about the development of speed and accuracy in keyboard skills. The basic question is simply this: what are the processes which make it possible for an operator starting at some 10-15 wpm to reach speeds of 60-80 wpm after suitable training and experience?

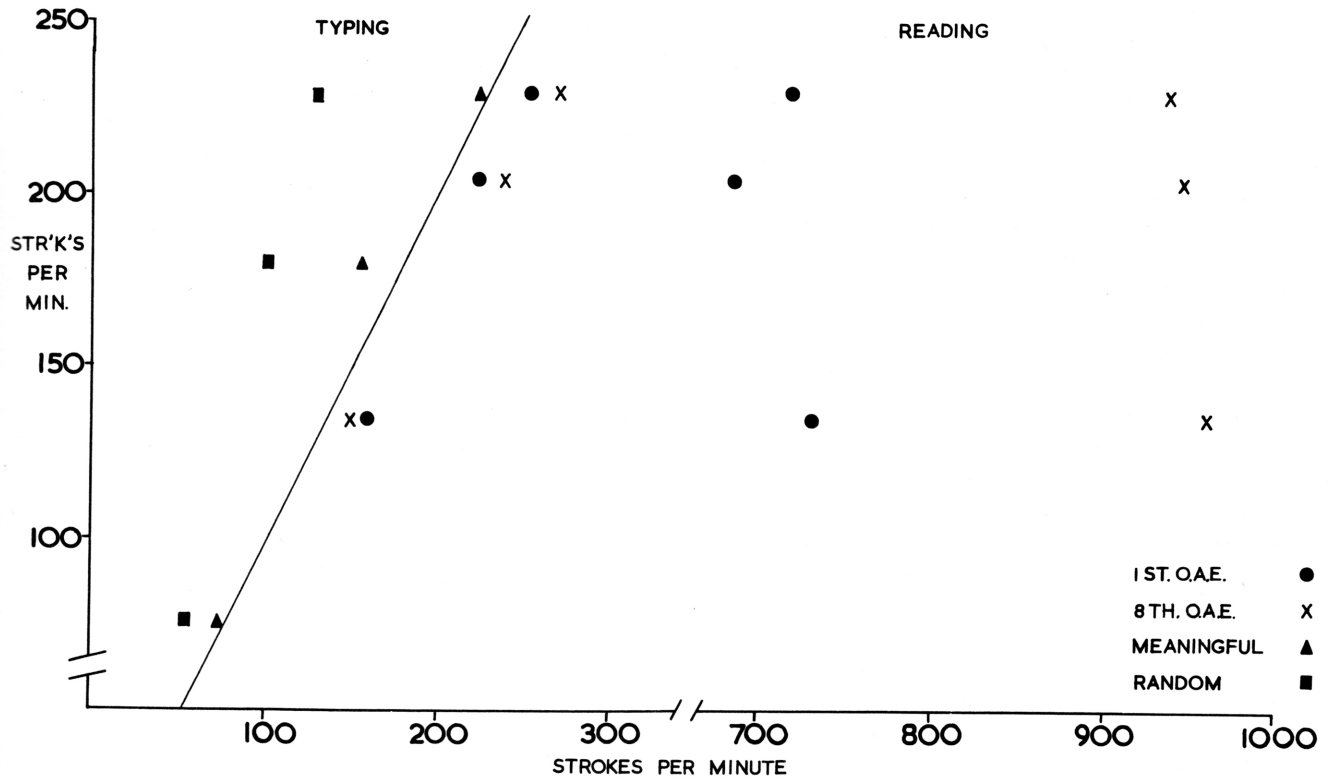
In a series of pioneer studies in the last decade of the nineteenth century, Bryan and Harter plotted the learning progress made in morse reception and transmission, and demonstrated the existence of so-called plateaus, that is to say, periods during which there appeared to be no further progress in efficiency followed by immediately demonstrable increases in speed. They inferred from their studies that these plateaus were the periods during which trainees consolidated their previous learning and, in particular, were able to move from dealing with the material letter by letter to handling small groups of letters at a time: they would cease to hear a-n-d but receive instead the configuration 'and'. Similarly it was held that they would cease to transmit letter by letter, but begin to generate increasingly large groups of letters. Bryan and Harter referred to this process as the acquisition of higher habits, and we have continued to think about the matter in these terms. In the practical field it is a common enough experience to find people read unfamiliar words which look sufficiently familiar in the wrong way. It once took me several exchanges with successive proof-readers to persuade them that 'digram' was not the result of mis-typing 'diagram'. And it is fairly safe to assume that many a copy typist employed by a tyre wholesaler might get into trouble when having to send a letter to a Mr Dunlap.

It has, however, not been very easy to demonstrate this progression to higher habits very directly and even today we still have to do it by inference. Up to a point, one can look at many of the problems concerned in keyboard training in the laboratory, and we have done so in a series of studies. One attempt to get at the development of higher habits involved the use of a ten-finger keyboard, and lists of words made up from the ten letters: ADEHLNORST. It is possible to generate quite a lot of words made up from these ten letters, and to make up several sub-vocabularies in turn. We argued that if we trained subjects on one sub-vocabulary and then transferred them to another we would see no decrement as long as our subjects were still operating letter by letter, since all vocabularies were made up of the same ten letters, but that we should expect a decrement if subjects had begun to type in some form of groups. Training one group of subjects on a hundred word vocabulary we did not find any decrement upon transfer to another hundred word vocabulary, but training a second group on a ten word vocabulary we did find a marked decrement on going to another ten word vocabulary. Both groups were transferred after the same amount of practice on their initial alphabets. We inferred that during the time available, it had been possible for subjects to learn to generate the ten word groups making up the short vocabulary but not the hundred word groups making up the large vocabulary and that the results appeared to demonstrate the original contention.

We can consider language as being constituted of elements which can be assembled with varying degrees of structure: at one end of the scale we have complete randomness, produced by assembling letters into groups by drawing them out of a hat, while at the other end of the scale we have the highly orderly, ie redundant form of combination which is everyday language. The people concerned with the characteristics of language have applied these concepts and constructed material which ranges from complete randomness through various approximations to English, to completely intact language. Such material has been used to study reading habits, memory, etc. It has also been used in typing studies. In general it has been shown that the more random the material the slower the speed of performance, and it is generally held that fast reading speeds of ordinary language are achieved by virtue of the fact that the reader can take full advantage of the known redundancy of the material. Similarly, it has been shown in a number of small studies that typing material of a more random nature than ordinary language produces slower typing speeds when the subjects used were experienced operators.

What we are trying to do is to apply some such technique to study the progress of acquiring efficiency in typing skill. We proposed to test typists at varying levels of proficiency by giving them an ordinary speed test and a range of material varying in structure. By comparing typing speeds obtained from the standard speed tests with the performance shown on the special tests it might then be possible to make inferences about the degree to which structure could be utilised at different levels of typing proficiency. As long as the scores were identical one could assume that only the lowest order of structure was in play; as soon as the special tests began to show a slowing down relative to the standard we could assume that this indicated the beginning of a limitation imposed by the structure of the special test. By asking our subjects to take reading tests of the same material we would also be able to make statements about the possible limitations imposed by structure on the input side in relation to typing proficiency.

It should be pointed out that the results presented here are very



much 'pilot data'. We were fortunate to find a teacher and her principal who were willing to let us use their students several times to improve our methods of testing as well as the material used. It is clear that it would be almost impossible to do this kind of work in a laboratory. For one thing, the subjects must be used to a particular machine if they are to achieve good performance. One pays for this by not having everybody use the same machine or having everybody operate under exactly the same conditions. But on the whole this seemed a worthwhile try. We hope to be able to repeat these studies in the coming year in at least two other colleges and on a longer time-scale.

Method

The subjects were some sixty or seventy students at the Mid-Warwickshire College of Further Education, Department of Commerce, and they were in three groups at different levels of typing proficiency. On separate occasions, and always in their own groups, they were given a number of typing and reading tests, the former in groups, the latter individually. All subjects were given standard speed tests provided by their instructors. The special tests were groups of letters arranged at random (R), meaningful words (m) such as town names arranged in random order, first order approximation to English and eighth order approximation. (The first two tests are due to Conrad, personal communication, the other two are taken from Morton). The manner of generating R material results in groups in which all the letters of the alphabet appear with equal frequency while in all other special tests the letters tend to appear with the expected frequencies of letters in the English language. This may place a limitation on the usefulness of our data. The two approximations to English were also given as reading tests. The students were instructed to pay attention primarily to accuracy. Each typing test lasted for three minutes. The reading tests required the reading of some 200 words.

Results

The figure shows the results obtained in terms of strokes per minute for different groups of data. The vertical scale represents achievement in the standard test, the horizontal scale achievement in the special tests. One group of subjects was tested twice within a few weeks and both sets of comparisons are shown. Reading speeds have been converted to strokes per minute for this purpose. Errors were scored but are not shown (in general there were more errors the more random the material). Note that the diagonal line indicates equality between scores on standard and special tests. Thus datum points lying to the left of that line indicate that the speeds obtained in the special tests were slower than in the standard tests, while points to the right indicate that speeds were higher than those obtained in the standard tests. Note that fastest standard mean is approximately 45 wpm.

It will be seen that as far as these means are concerned there is little difference between standard and special tests until we get beyond some 25 wpm, 175 spm. From then onwards the scores for R appear to become slower relative to the standard and remaining special tests, and there is some indication that they might have reached an asymptote. From this we infer that it may be possible to achieve relatively low speeds of performance by typing letter by letter, but that at the higher levels of proficiency some utilisation of structure is needed. The reading results show the expected difference between the two tests, but these speeds are totally unrelated to the students' typing speeds.

These preliminary results suggest that improvement in typing speed beyond some 35 wpm depends upon the ability to utilise structure on the output side.

The most immediately interesting point concerns the possible implications of our findings, if confirmed, for training and performance. Let us deal first with two points of criticism. Firstly, it is quite possible that our choice of randomness could weight the result towards lower letter by letter speeds than can actually be obtained. It will be recalled that the R material had the letters appear with equal frequencies and it can well be argued that typists under training do not have the same amount of experience with the less frequently appearing letters. We hope to overcome this difficulty in our next series by generating R material in which letters will still appear in random order but with the letter frequencies appropriately adjusted. It is also worth noting that our observed R speeds continued to increase with increasing proficiency in standard tests; it was the fact that they did not increase as much as the standard speeds on which we based our present argument. Secondly, we can at present argue only by a comparison of means and not by plotting individual datum points for each subject. When we do this the picture is rather less clear and we must assume that this is most likely due to variability introduced by our preliminary methodology. We would therefore expect to be able to obtain subject-by-subject correlations in the main experiments. Having said this, it is only fair to say that we are presenting here a first attempt at utilising an established method in a new setting and that we would not wish to make highly specific statements at this stage. There is now at least one well-known training establishment in which students are said to be trained to acceptable levels of performance by a method which relies very heavily on the letter-by-letter approach, while on the other hand there has always been a tendency to teach typing in terms of groups of letters, and more recently great stress has been placed on the need for using meaningful material at the earliest possible stage. The main point about the letter-by-letter approach is that it lends itself much more easily to the automation of training because of the relative simplicity of the hardware required. The main point about the alternative approach is that it appears to be the more rational thing to do, since language, after all, consists of meaningful words and phrases rather than of an accumulation of letters. It has also been held to be less boring to start with meaningful material early on.

Perhaps the answer may well be in a suitable combination of methods: as long as one is satisfied with speeds in the 30 wpm region, fast letter-by-letter training may well meet a not inconsiderable need for reliable copy-typing. Beyond those speeds, until we obtain confirmation to the contrary, we must assume that it is necessary to generate patterns of letters, and that this will still have to be practised. From the point of view of the individual student's dificulties, the possibilities of using our special tests as diagnostic tools may offer a further opportunity to prescribe remedial training. If, with refinement of tests, one possible reason for failure to achieve higher speed could be shown to be an inability to acquire the necessary higher habits it may not be too hard for the teachers to assist the student.

Clearly if our results and those obtained by other authors earlier continue to present the same picture, one of the next steps will be to apply these tests to people trained by different methods to see whether differences in training can be detected by this means. Following on from this we would want to build up suggestions for training schemes ourselves and put these to the test.

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